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ON THE PROMOTION OF DESIGN FACILITIES IN INDUSTRIALLY DEVELOPING COUNTRIES.

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ON THE PROMOTION OF DESIGN FACILITIES IN INDUSTRIALLY DEVELOPING COUNTRIES

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This paper is concerned with outlining ways and means of developing design facilities, the awareness of the paramount importance of design work and of its significant influence on national economy being first emphasized.

Design facilities are regarded as comprising the availability of competent staff, production equipment, testing apparatus and technical documentation. Methods of preparing designers through tuition and training are discussed, and the importance of disseminating design information and data is pointed out.

For industrially developing countries, the current accute shortage of design facilities imposes an additional objective, namely that of the most efficient use of available facilities.

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INTRODUCTION

In an industrial country, various industries would have passed, during their natural path of development, through several stages, viz.:

(i) Copying and adaptation,
(ii) Improvement, modification and development,
(iii) Creation and invention.

Transfer from one stage to the next mainly depends on the rate and extent of accumulating knowledge and experiences in the particular industry. The natural development of industry would evidently extend over a relatively long period of time.

Developing countries who intend, however, to get industrialized within fairly close limits of time, would strive at increasing the rate of industrial development by the following means:

(a) Higher capital investment in industrial projects,
(b) Increased rate of technical education and training,
(c) Development of potential creative abilities in the industrial field.

The first two means are quite well understood, while the vital importance of the third item is not as yet fully appreciated, in spite of the fact that the design function forms the hub of all engineering activity, without which no genuine development could be achieved. It is this aspect of problems facing industrially developing countries which is dealt with in this paper.

It may not be too difficult to erect and run extensive industrial concerns, but it is not at all easy to effect real improvements and developments in materials, processes, equipment and products without advanced expert knowledge and creative ability in the field concerned. The continued and tedious search for furnishing better, though cheaper, industrial products evolves from the keen competition between industrial concerns who, in some cases, fight all the way for their very existence.

Advanced technical knowledge now forms effective means for exerting economic as well as political pressure, hence the absolute need for the rapid and intensive development of national resources of creative abilities, should a developing country endeavour to secure its industrial status and national income.

CONTEMPORARY INTEREST IN DESIGN WORK

It is not just a coincidence that pronounced interest in and increased awareness of the importance of design has recently been displayed by the frequent holding of relevant conferences* and symposia, and the publication of specialized reports, studies and papers on design (e.g. 1 - 27)**. This contemporary interest is quite rightly justified in a rapidly developing and keenly competitive world, in which design is playing a most significant role in the battle for industrial survival and enhanced productivity. The growing awareness of the importance of good engineering design and its impact, through production and relevant sales on the national income has led industrially developed countries to pay careful attention to potential creative faculties and to ways and means of developing these faculties through university tuition and industrial training.

Sound designs, innovations and the development of more efficient production techniques and engineering materials should be the aim of serious intentions for industrialization. Possession and careful

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*e.g. First Conference on "Engineering Design Education", held at Case University, 8th. - 9th. September 1960.

Conference on "Design Methods", held at Imperial College, London, 28th. September 1962.

Conference on "The Practice of, and Education for, Engineering Design", held at the Institution of Mechanical Engineers, London 16th. - 17th. October 1963.

Conference on "Teaching of Engineering Design", Scarborough, 1964.

& Conference on "Organization for Design", to be held by the Institution of Mechanical Engineers, London, on 15th. and 16th. February 1966.

**See references at end of paper.

handling of advanced technical information have proven to be quite a decisive factor in the stability of the industrial set-up. Scientific and engineering achievements, successfully applied in the industrial field, shall remain for a long time the basic criterion for survival.

In the light of these contemporary trends of rapid technological progress, and ever increasing rate of world competition, industrially developing countries are to be strongly recommended, at all stages of development, not to overlook the importance of design work, at least in as far as it provides safeguard against technical isolation and economical pressure. The establishment of industrial concerns should by all means be accompanied by serious and intensive studies of relevant techniques, equipment and products as a pre-requisite for current and future independent creative work.

The well known "Feilden Committee Report" (2, 3, 4) spared no effort in emphasizing the paramount importance of engineering design as it affects products' performance, reliability, appearance, delivery and price. To quote but a few of Feilden's words (3) are the following:

> "Every industry is dependent upon engineering for capital plant and equipment; the quality of engineering design is, therefore, a major factor in costs and productivity.
>
> Where the importance of design is appreciated and the design team is adequately staffed and given its proper status, British products are outstanding".

Principal conclusions and recommendations of the committee (2) include:

(a) Emphasis of vital importance of design in engineering and consequently in the national economy.

(b) Urgent need for more able people to train as professional engineers, especially as designers; encouragement of more talented engineers to make their careers in design.

(c) Need for increase of the prestige of design and the status of designers.

(d) Establishment of institutes for advanced studies in particular fields of design in close association with industry; establishment of a higher degree in engineering design.

(e) Encouragement of good design practice and of the preparation of design manuals.

It should be evident from these statements to what extent a well developed industrial nation is deeply aware of the significant role played by design and its impact on national economy. It must be, herein, pointed out that these symptoms should not be looked upon as being mainly confined to developed countries, as all nations marching along the hard and long route of industrialization shall, sooner or later be faced with the inadequacy of design facilities, in case no provision to avoid such situation be taken in the industrial plan.

NATURE AND LIMITATIONS OF DESIGN

As expressed in a recent report (4), design may be regarded as "the highest manifestation of the art and science of mechanical engineering". How true and precise is this statement.

The term 'design' may be used to denote creative planning or development work set out to meet specific requirements, making best use of materials and processes known to mankind. Good designs should aim at minimum size, mass and cost, also maximum efficiency and endurance, and best appearance.

In his approach to the problem, the designer would try to formulate as many solutions as possible, which would meet the stipulated requirements. He would then analyse these solutions in the light of his knowledge of relevant engineering subjects in an attempt to reach the most acceptable and promising solution.

A particular feature pertaining to design work is that no absolute criterion of success or perfection does exist. The designer would, in general, be faced with several criteria which most often conflict with

each other. Under such circumstances, the designer would have to seek some compromise, guided by his analysis, talent and professional experience. This type of work would, no doubt, call for men with creative abilities, who should be given proper tuition and training before they can be permitted to practice 'Design Engineering'.

Any industrial set-up should take all necessary measures as to develop its potential creative faculties and promote material aspects of design facilities, should stability, progress and increased productivity be sought.

DESIGN FACILITIES

By design facilities is meant intellectual and material resources made available for carrying out design work.

Intellectual facilities constitute competent designers who have acquired sufficient technical knowledge and experience, in conjunction with inherent abilities, so as to be able to tackle design problems assigned to them. A good designer is expected to possess the following capabilities:

(a) Basic theoretical background in engineering,
(b) Professional experience in actual engineering concerns,
(c) Training in design work in competent development and research departments;
(d) Technical imagination and creative ability.

The fact that many industrial countries suffer from lack of designers has been discussed in recent publications (e.g. 2, 4 and 7). Great emphasis has been placed on the encouragement of graduates with high intellectual capacity to take up design engineering as a career. Preparation of designers through university tuition, advanced studies and training in industry has also received careful attention (8 - 26).

On the material side of design facilities are the availability of production equipment and testing apparatus. In industrially developed countries, it would be feasible to expect many concerns to possess their own facilities. This would be justified in an advanced stage of development in a country living mainly on its export of industrial products. Under such circumstances the rule in the battle of productivity would be 'produce or perish'. It would be superfluous, in this paper, to emphasize the significant role of design in productivity.

In industrially developing countries, however, limitations in intellectual and material resources call for planning schemes for the best utilization of available facilities. Design work may thus be conducted in close co-operation with industrial concerns, research organizations and university laboratories, until the extent of work becomes so extensive and promising as to justify having independent facilities.

Industrially developing countries are recommended not to overlook, at any stage of development, the importance of design work by planning new industries to include development departments, with reasonable production, testing and research facilities.

Last but not least of material aspects of design facilities are the preparation, documentation and dissemination of design information and data. This would be achieved through the co-operation of professional institutions, universities and industry.

As qualified manpower is, in my opinion, the keystone of design facilities, problems facing the preparation of competent designers are, hereunder, discussed in detail. The additional problem, facing industrially developing countries in particular, i.e. that of the most efficient use of professional engineers and in particular of designers, is also outlined with recommendations as to some plausible solutions.

TEACHING OF DESIGN

This aspect of design facilities has been, in recent years, the subject of numerous discussions, reports and papers (8, 9, 11, 12, 14, 16-19, 21, 22, 24-26), relevant methods, experiments and trends being examined at great length. It is not intended in this paper to discuss the problem of the theoretical training of designers in detail, but rather to give a brief evaluation of present state of affairs.

Owing to intensive concentration on basic sciences during the last two decades, time allocated to design teaching in many universities was seriously affected. This unfortunate deviation in engineering education is responsible for the present shortage of designers as suffered by almost all countries whether industrially developed or otherwise. This phenomenon, together with the genuine understanding and recognition of the importance of design, by men of learning, academic and industrial bodies seem to be the direct cause for what we may call contemporary "Reappraisal of Engineering Design".

By virtue of their nature, engineering design problems do not, in general, have single definite solutions. The number of unknowns, in the design problem, usually exceeds the number of equations, hence the need for making plausible assumptions, and carrying out more than one trial before a reasonable solution could be reached. Moreover, the designers may, generally, be confronted with a number of possible and feasible solutions among which he will have to seek the most suitable answer in the light of his judgement and experience.

Design approaches may be broadly classified in two main categories, namely:

(a) Traditional Approach: This is based, to a substantial extent, on previous experience, empirical formulae and trade codes. Such approach had been in common use a few decades ago.

(b) Rational Approach: This is founded on the application of scientific information and technical data, through analysis

and synthesis to the development of solutions which are then evaluated before relevant decision be taken as to the most suitable solution to the problem under consideration.

This latter approach evolved from the rapid scientific and technological progress, also from contemporary scientific attitude and call for most efficient utilization of engineering materials and other resources. It represents the modern trend in design engineering.

The analysis of the methodology of design has shown that education of engineers differs from that of scientists in that design forms the hub of engineering activities; consequently the educational set-up shall have to be directed to this fundamental objective.

Standard methods of teaching design have so far been virtually methods dealing with "Case Studies" of somewhat orthodox nature, for which relevant literature is available, and the extent of originality is limited to some extension of existing knowledge. Of these standard methods two types can be identified, viz.:

(a) Design studies of complete projects, with work carried out in great detail. This method (as mainly adopted on the Continent) has been found quite effective in teaching design of rather well known components and units.

(b) Design studies of few elements with emphasis mainly placed on theoretical and analytical work. This method would hardly serve the purpose of design teaching, as analytical work would have already been tackled in respective fields.

"Case-Study" methods of teaching would, by no means, be considered adequate, owing to the fact that they really constitute, in the main, copying work with no or at best little creative contributions.

Case studies would, however, be most suitable and essential in the capacity of a first stage course in design. Preparation of designers should, however, go far beyond these studies.

Recent trends in design methods show that two further stages should be incorporated in the teaching programme; these are:

(i) Case Histories: in which the evolution and development of existing engineering design solutions are studied in detail, e.g. the evolution of gearing, transmission systems, machine tools etc., alternative designs being thoroughly examined.

These would be a necessary requisite before the final stage which follows could be undertaken.

(ii) Creative projects: in which work calling for technical imagination and inventive ability should be attempted. These studies should, by all means, be carried out in close association with industry whenever possible.

This would lead us eventually to the importance of training designers in industry in line with their basic training in academic institutions.

TRAINING IN INDUSTRY

The conception of training designers in industry is quite a serious one. Such training, which should bridge design and production engineering aspects, must never be overlooked if preparation of competent designers is sought. Designers should not only be given access to research and development departments in leading industrial concerns, but as pointed out before, closer co-operation between academic institutions and industry should be dealt at an earlier stage by undergraduate as well as by postgraduate students, through the organization of corporate projects carried out in collaboration with and to the benefit of industry.

The need for forming large teams of design engineers has been expressed on several occasions, the idea being already put in actual practice several years ago. Trainees would preferably be allowed to join a design team, and should be given some degree of responsibility

that would be increased in liaison with abilities displayed in the course of work.

Without adequate training in industry, designers may not be expected, in general, to furnish the most suitable and practical designs, within time limits set for the job. This may, in some cases, entail serious financial loss.

DESIGN DATA

One of the principal recommendations proposed for the promotion of design facilities is the preparation, documentation and dissemination of design data (2, 27). Measures should be taken by professional, academic and research institutions to set up joint committees for the preparation of authoritative design data sheets and manuals, necessary funds being allocated for the purpose. Publication of such data would naturally be of invaluable assistance to designers.

Moreover, should some system of documentation of past designs be arranged in such a manner as to facilitate identification and location of such designs, much time and effort could be saved on the part of designers who would then concentrate on new designs only. If technical information appearing in engineering and science journals and periodicals could also be made available and be properly classified, effective use of technical literature would be made possible for teams of designers.

All these measures would, no doubt, greatly contribute to the enhancement of design facilities in an industrial community.

EFFICIENT USE OF DESIGNERS

A special problem facing industrially developing countries is the relatively limited number of professional men available. Such deficiency, which may be reduced or even eliminated over the years, through suitable education and training, should find an immediate and ready solution

through the proper use of scientific, technological and technical manpower.

As far as design facilities are concerned, men of experience in industry should take, besides their original duties, active part in schemes set up for the preparation of engineering designers, through some part-time arrangement.

Professional engineers in industrially developing countries should, by all means, be relieved from non-technical duties which could otherwise be carried out by non-engineers. Existing abilities should be developed to the fullest extent and plans for improving the quality and quantity of design engineers should come into immediate effect.

SUMMARY AND CONCLUSION

In this work the phenomenon of contemporary reappraisal of design engineering is pointed out and relevant means of harnessing and promoting design facilities are investigated.

The nature and limitations of engineering design are discussed and methods of its teaching are examined. It is herein established that the rational approach to design problems should be followed, and that an effective scheme for the preparation of designers should be based on a three stage programme, viz. case studies and case histories culminating in creative work.

The importance of training designers in industry is emphasized, and close co-operation between industry and academic institutions is advocated. Design studies should include projects carried out in collaboration with and to the benefit of industry.

A substantial contribution to design facilities may also be effected through the preparation, documentation and dissemination of design data and relevant technical information.

Industrially developing countries are recommended to make most efficient use of their rather limited resources of professional engineers and of material facilities, with a view to overcoming current shortage therein. Ambitious industrial plans should incorporate suitable schemes for the preparation of engineering designers, who would no doubt be the key figures responsible for genuine technological progress in the highly competitive world of today.

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